Variation in the spread of white clover plants growing in competition with different grasses

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Abstract

An experiment was conducted to determine whether some white clover cultivars might spread over a greater ground area more successfully when in competition with particular grass species. We measured the area and height of 300 different white clover genotypes (20 genotypes from each of 15 contrasted cultivars) over a two-year period when these were inserted as plants into grazed swards of either perennial ryegrass (*Lolium perenne*) L., tall fescue (*Festuca arundinacea* Schreb.) or browntop (*Agrostis capillaris* L.). The type of companion grass strongly influenced the spread of white clover plants, but a particular group of cultivars (Tahora, Prestige, Crau selection) proved to spread more with all three grasses. Seven cultivars from the USA (Regal, Osceola, BL-H, SRVR, Brown Loam 2, Louisiana S1 and MSWC2) all spread poorly relative to New Zealand cultivars. Although there was no evidence that these cultivars spread more in association with particular grass species, strong differences between genotypes within cultivars were detected and there was some evidence that certain genotypes did better with particular grasses. These results suggest that there may be scope for further improvement of the competitive ability of white clover. Promising genotypes have been identified to assist attempts at improving white clover competitive ability by further selection.

Additional key words: *competitive ability,* Lolium perenne, Festuca arundinacea, Agrostis capillaris, Trifolium repens

Introduction

There have been numerous studies comparing the growth of white clover (*Trifolium repens* L.) in competition with different grass species or grass cultivars (e.g., Chestnutt and Lowe, 1970). These studies have indicated that white clover can coexist more successfully with tufted grasses than with stoloniferous grasses. However, comparatively little attention has been paid to determining the importance of variation between white clover cultivars in influencing the outcome of competition with grass species (e.g., Camlin, 1981).

The results of an experiment are reported where fifteen different white clover cultivars were grown with three grass species of differing morphology and seasonal growth pattern: perennial ryegrass (*Lolium perenne*), tall fescue (*Festuca arundinacea*) and browntop (*Agrostis capillaris*). Perennial ryegrass is a densely-tufted, cool-season, perennial grass forming a moderately dense sward when grazed. Tall fescue is a tufted perennial and forms a more coarse, open sward than ryegrass when grazed. Browntop is a rhizomatous, summer-growing grass which forms a dense, close turf (Whyte, Moir and Cooper, 1959). A number of studies have shown a positive association between perennial ryegrass and white clover (Kershaw, 1959; Harris and Brougham, 1968; Harris, 1973), but a negative association between browntop and white clover (Brown, 1939; Kershaw, 1958; Jackman and Mouat, 1972).

A particular interest in this study was to determine whether plants of white clover cultivars or genotypes showed specific compatibility with each of three grass species, or whether the most competitive white clover plants were consistently superior with all grass types.

Materials and Methods

Swards of *Lolium perenne* cv. Grasslands Pacific (from seed with 65% endophyte), *Festuca arundinacea* cv. Triumph and *Agrostis capillaris* New Zealand Certified were sown at 50, 30 and 21 kg/ha respectively in 15 m x 20 m paddocks at AgResearch, Grasslands Research Centre, Palmerston North in October 1990. There were two replicate paddocks of each grass species arranged in a randomised block design. These swards were intermittently grazed by sheep and in January 1992 all volunteer white clover was removed by spraying with dicamba (10 ml/l).

In May 1992, 20 individual genotypes of each of 15 white clover cultivars (Table 1) were planted into each paddock at 1 m spacings (i.e., a total of 300 white clover genotypes per paddock). The same 20 genotypes of each cultivar (raised from cuttings of stolon tips and grown in a glasshouse for 10 weeks) were planted into each paddock.

White clover plant size was recorded regularly from July 1992 to November 1993, immediately before grazing by sheep. For each white clover plant, measurements were made *in situ* of (i) the length of the longest plant axis, (ii) the mean width perpendicular to the longest axis, assuming an elliptical shape for each plant, and (iii) the mean height of leaf lamina. A value of zero was recorded for each measurement if the plant was dead. The linear measurements of (i) and (ii) were used to calculate an area for each plant using the mathematical formula for an ellipse. In this paper, results are presented for a single measurement made in September 1993, in order to assess the development of plants at that time.

During the period of measurements, the areas were grazed by sheep in October, November and December 1992 and January, March, July, August and October 1993. Paddocks of perennial ryegrass and tall fescue were mown to a height of 50 mm immediately after grazing on October and December 1992 to remove flowering stems which had not been consumed by stock.

Table 1. White clover cultivars used in the experiment, with description and origin.

Cultivar	Description	Origin
Grasslands Huia	Medium leaf size	NZ
Grasslands Kopu	Large leaf size	NZ
Grasslands Tahora	Small leaf size	NZ
Grasslands Challenge	Large leaf size	NZ
Grasslands Demand	Small-medium leaf size	NZ
Grasslands Prestige	Small leaf size	NZ
LLS	Large leaf size	NZ
Crau selection	Large leaf size	NZ
Regal	Ladino	USA
Osceola	Ladino	USA
Louisiana S1	Large leaf size	USA
Brown Loam S2	Large leaf size	USA
SRVR	Ladino	USA
BL-H	Large	USA
MSWC2	Medium	USA

Data were analyzed as a split-block design, with grass species as main blocks within each replicate and genotypes nested within cultivars for analysis of variance. The data were analyzed by the Statistical Analysis Systems package (SAS).

Results

In general, tall fescue depressed the spread of individual white clover plants least severely, perennial ryegrass was of intermediate severity and browntop depressed spread most severely (Table 2). There was a clear difference in the mean spread of different white clover cultivars (cultivar effect significant, $P<0.001$) with Regal developing the smallest plants and Tahora developing the largest plants, when averaged over the three grass species (Table 2). However, there was no evidence that competition from the different grass species affected the white clover cultivars differentially (cultivar x grass interaction effect non significant at $P>0.1$). The ranking of cultivars remained more-or-less identical regardless of the identity of the grass species. This result suggests that the ability of these cultivar populations to compete successfully with these three grasses was not due to morphological or phenological adaptations which were specific to each grass species. The three white clover cultivars Tahora, Prestige and Crau selection were superior with all three grasses.

Large differences were also detected among genotypes within each cultivar (genotype effect within cultivar significant at $P<0.001$). For simplicity the values for the 300 individual genotypes are not presented, but this information can be obtained from the authors if required. In addition, there was some evidence that genotypes responded differently to the presence of the different grasses (grass x genotype effect within cultivar significant at $P<0.05$) and the range of values is presented in Table 2.

The grasses also affected the height of the leaf canopies of the white clover plants (Table 3). Overall, canopy height followed similar trends to lateral spread, with white clover canopies shortest in browntop, intermediate in ryegrass and tallest in tall fescue. However, the effect on canopy height was generally small in absolute terms at this time of year. Within each grass species, white clover canopy height was strongly positively correlated with lateral spread when plants were growing in browntop ($r=0.78$, $P<0.005$) but there was little relationship between height and lateral spread in either ryegrass ($r=0.30$, NS) or tall fescue ($r=0.26$, NS).

Table 2. Mean size and range of sizes of the 20 genotypes of white clover plants within each cultivar when grown with each of the three different grasses (September 1993).

Cultivar	Mean area per white clover plant (cm^2)				Range of area per white clover plant (cm^2)		
	Ryegrass	Browntop	Tall Fescue	Mean	Ryegrass	Browntop	Tall Fescue
Regal	874	87	1562	841	0-2382	0-592	0-3995
Osceola	984	31	1799	938	0-3299	0-324	37-4115
BL-H	1243	133	1674	1016	0-3579	0-713	36-3325
Challenge	714	465	2208	1129	0-1847	0-4059	174-6927
SRVR	1027	132	2306	1155	0-4343	0-774	17-8151
Brown Loam S2	1276	293	1977	1182	33-2844	0-2118	0-6428
Louisiana S1	1646	235	1678	1186	123-5321	0-4205	0-3414
MSWC2	1303	356	2097	1252	122-3457	0-2995	0-4689
Kopu	1425	295	2043	1254	27-3724	0-1946	201-4459
Huia	2175	640	2308	1708	369-4204	0-3218	0-4554
Demand	2223	852	2233	1769	463-4100	0-2923	174-5655
LLS	2259	689	3068	2005	536-4835	0-3412	399-5742
Crau selection	2926	950	2956	2277	0-6535	0-2738	0-7033
Prestige	2204	1245	3642	2364	443-5160	0-4655	511-9953
Tahora	2612	1361	3599	2524	168-5148	0-6208	596-7811
SEM		239		138			
Mean	1659	518	2344	1502			

Table 3. Mean height of plants of white clover cultivars growing with different grass species (September 1993).

	Height (cm)			
Cultivar	Ryegrass	Browntop	Tall Fescue	Mean
Regal	6	1	6	4
Osceola	5	1	7	4
BL-H	5	1	8	5
Challenge	5	3	9	6
SRVR	5	3	8	5
Brown Loam S2	6	1	8	5
Louisiana S1	5	1	8	5
MSWC2	5	2	8	5
Kopu	5	2	8	5
Huia	6	2	8	5
Demand	5	3	11	7
LLS	8	3	9	7
Crau selection	6	4	8	6
Prestige	6	3	8	6
Tahora	5	3	8	5
Mean	6	2	8	

Discussion

The two components of competitive ability examined were the lateral spread (or area) of each plant and the height of the leaf canopy. These components do not necessarily translate to yield per unit area, but rather are indices of the ability of the white clover plants to penetrate the surrounding grass sward and develop new stolon, leaf and root material.

Despite clear differences in the stature and seasonal growth of the grasses, three white clover cultivars (Tahora, Prestige, Crau selection) were consistently superior in all three grass types. Similarly, the seven cultivars from the USA (Regal, Osceola, BL-H, SRVR, Brown Loam 2, Louisiana S1 and MSWC2) all performed poorly relative to New Zealand cultivars. This finding suggests that the competitive ability of these white clover cultivars tended not to be specific to the identify of the competing grasses. Woledge, Davidson and Dennis (1992) also observed little difference in performance between small-leaved and large-leaved white clover cultivars when grown in association with either perennial ryegrass or tall fescue during the spring period.

It is perhaps not surprising that the grasses did not differentially affect the spread of the cultivars, because during their respective plant improvement programmes all the cultivars have been selected as spaced plants in the absence of competition.

Despite not detecting differences in the effect of grass species on particular white clover cultivars, we did find some evidence that there was a strong difference in the spread of genotypes within each cultivar and that there may be a differential response to grasses at an individual genotype level. The concept of specific combining ability (e.g., Turkington 1983; Evans *et al.*; 1985, Collins and Rhodes, 1989), where particular white clover genotypes might be suited to combining with particular grass species characteristics, is therefore not supported by our data at a cultivar population level but is supported at the level of individual genotypes. This finding suggests scope for improving competitive ability by further selection, and reinforces the importance of selecting white clover under competition rather than as spaced white clover plants growing in monoculture.

Both the height and lateral spread of plants are characteristics considered to be important determinants of competitive ability, when combined with other attributes (Grime, 1979; Grime, Hodgson and Hunt, 1988). The lack of a clear relationship between height and lateral spread in this early spring period for white clover cultivars in ryegrass and tall fescue indicates that, when selecting important characters for competitive ability, there may not be a strong link between height and lateral spread.

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